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13. ABSTRACT ***(Maximum 200 Words)***

The objectives of this project are to restore a parcel of land in Beale Air Force Base, California, to native habitat, and to compare the efficiency of high, medium and low-input methods of plant establishment. The present report summarizes the findings resulting from monitoring of oaks established from field-planted acorns and from nursery-grown seedlings. Both groups of trees were protected, subsequent to establishment in the field, with one of three different kinds of tree protectors. Monitoring at two dates included survival and vigor. Statistical analysis of results to date indicate that survival over the growing season is significantly better for acorns than for seedlings, but when survival is assessed over a 12-month period, there is no statistically significant difference. Type of tree protector did not have a significant effect on survival, but did have a significant effect on plant vigor. Challenges at the site include extremely low plant survival, thought to be due to high vertebrate pest populations. Comparable planting techniques used at other sites have resulted in survivals of 85 - 95% over a 2-3 year period, as compared with an average survival of approximately 26% at this site. Report includes suggestions for future plantings.

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INTRODUCTION

Current riparian restoration efforts utilize a variety of materials and methods, all of them aimed at optimizing plant growth and survival. Some restoration efforts are very costly. Amont the variables that are likely to have a significant effect on project cost and plant performance are method of plant propagation, irrigation method, weed control, and protection of plants from herbivores, herbicide and the elements. Our experience has suggested that there are some more cost-effective ways of restoring a parcel of land than the commonly utilized ones. To be sure, some methodologies will be appropriate for some situations and not for others. The project that is currently under way at Beale Air Force Base in California (Award No. DAMD17-99-2-9051) is an effort to restore a parcel of land there while investigating the economics of efficient restoration methodology. We are planting oaks of different ages, and nurturing and protecting them in various ways, in order to identify the factors that might be responsible for optimal and economical plant growth.

BODY

Protocol: Nov. 2000 – Oct. 2001

1. Dec. 2000: Locally collected acorns planted in rows 2, 5, 9, 10, 14, 18 and 21 of Field 7 to supplement the low plant numbers surviving from the first planting of Dec. 1999. Acorns planted ten feet apart, in planting sites adjacent to original planting sites, so that the same drip emitter could still be used.
2. May 2001: Germinated seedlings protected with one of three different kinds of tree protectors, with these treatments randomly assigned in groups of five seedlings, in such a way that each treatment was represented in each treatment row. (**Attachment 1**)
3. Overwintering survival data collected for acorns and seedlings, May 2001.
4. Routine maintenance (irrigation and weed control) conducted throughout the growing season, 2001.
5. Oct. 2001: all plants monitored to assess overall survival (from planting date up to Oct. 2001) and survival from the period May 2001 through Oct. 2001. Vigor assessed on a 1 – 3 scale (1 = low vigor: few leaves, minimal branching, poor leaf color; 2 = high vigor: numerous leaves, moderate – extensive branching, healthy leaf color) for all plants still alive at monitoring date.

Results

1. Survival in May 2001 of trees planted as acorns in Fall 2000 was significantly different than the survival of trees planted in Fall 2000 as seedlings (**Table 1**). Survival of acorns was 44%; this figure would also include germination and emergence of acorns. Survival of seedlings was 67%. There was a significant replication effect. Survival in the ten replications varied from 25% to 84%.

2. Survival in October 2001 of trees protected in May 2001 was very significantly different for seedlings than for acorns (**Table 2**). Survival for acorns at this time was 57%; survival for seedlings was 37%. The variation due to replication was not significant for this variable.
3. There was not a significant difference in survival between seedlings and acorns, when the time period examined was from planting (Fall 2000) through October 2001 (**Table 3**). For this time period, the survival rate for trees planted as acorns was 27%; that of trees planted as seedlings was 28%. There was, however, a highly significant replication effect (replications reflecting positions in the field); survival in Field 1 (reps 1, 2 and 3) and in the northern portion of Field 7 (rep 10) was markedly higher than in the remainder of Field 7.
4. There was not a significant effect of type of tree protector on survival, when survival was assessed in October 2001 (**Table 4**). Percent survival with the three kinds of tree protectors was 46%, 45% and 51%, with milk cartons, Treepees® and Tree pros®, respectively.
5. Type of tree protection device had a significant effect on tree vigor, when vigor was assessed subjectively in October 2001 (**Table 5**). Trees protected by milk cartons, Treepees®, and Treepros® had vigor scores of 1.58, 2.15 and 2.03, respectively.

Table 1: Survival in May 2001 of oaks planted in summer and fall 2000 as acorns or seedlings.
Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Acorns	10	4.42	0.442	0.056507
seedlings	10	6.7	0.67	0.031178
rep 1	2	1.54	0.77	0.0338
rep 2	2	1.67	0.835	0.00045
rep 3	2	1.65	0.825	0.00245
rep 4	2	1.03	0.515	0.06845
rep 5	2	0.73	0.365	0.06125
rep 6	2	0.49	0.245	0.01805
rep 7	2	1.15	0.575	0.01805
rep 8	2	0.91	0.455	0.00245
rep 9	2	0.95	0.475	0.08405
rep 10	2	1	0.5	0.0578

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Trts	0.25992	1	0.25992	26.92541	0.000572	5.117357
Reps	0.70228	9	0.078031	8.083333	0.002323	3.178897
Error	0.08688	9	0.009653			
Total	1.04908	19				

Table 2: Survival in October 2001 of trees planted in the field as acorns or seedlings, and protected in May 2001. Data collected in Oct. 2001 only on those plants that had been alive in May 2001.

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
acorns	10	5.74	0.574	0.023516
seedlings	10	3.77	0.377	0.049357
rep 1	2	1.25	0.625	0.00045
rep 2	2	1.49	0.745	0.00245
rep 3	2	1.3	0.65	0.0002
rep 4	2	0.62	0.31	0.0032
rep 5	2	0.84	0.42	0.0338
rep 6	2	0.77	0.385	0.06125
rep 7	2	0.68	0.34	0.0162
rep 8	2	0.56	0.28	0.08
rep 9	2	0.78	0.39	0.1152
rep 10	2	1.22	0.61	0.045

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
trts	0.194045	1	0.194045	10.668	0.009742	5.117357
reps	0.492145	9	0.054683	3.006292	0.05832	3.178897
Error	0.163705	9	0.018189			
Total	0.849895	19				

Table 3: Survival of oak trees planted in Fall 2000 and monitored Oct. 2001.

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
acorns	10	2.67	0.267	0.037023
seedlings	10	2.82	0.282	0.046551
rep 1	2	0.97	0.485	0.00845
rep 2	2	1.24	0.62	0.0008
rep 3	2	1.08	0.54	0.0018
rep 4	2	0.33	0.165	0.01125
rep 5	2	0.26	0.13	0.0018
rep 6	2	0.15	0.075	5E-05
rep 7	2	0.38	0.19	0.0008
rep 8	2	0.24	0.12	0.0128

rep 9	2	0.28	0.14	0.0018
rep 10	2	0.56	0.28	0.0018

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
trts	0.001125	1	0.001125	0.251709	0.627917	5.117357
reps	0.711945	9	0.079105	17.69907	0.000107	3.178897
Error	0.040225	9	0.004469			
Total	0.753295	19				

Table 4: Effect of type of tree protector on survival, when survival was assessed in October 2001.

Anova: Two-Factor Without Replication

EFFECT OF TREE PROTECTION AVERAGED OVER PLANTING MATERIAL

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
milk cart.	20	9.24	0.462	0.07668
tree pees	20	9.095	0.45475	0.082362
tree pros	20	10.16	0.508	0.063891
REP 1	3	1.8	0.6	0.01
REP 2	3	2.3	0.766667	0.043333
REP 3	3	2.03	0.676667	0.004933
REP 4	3	0.76	0.253333	0.029233
REP 5	3	1.28	0.426667	0.057633
REP 6	3	1.63	0.543333	0.033633
REP 7	3	1.28	0.426667	0.060933
REP 8	3	1.5	0.5	0.07
REP 9	3	1.64	0.546667	0.040833
REP 10	3	2.53	0.843333	0.027433
REP 11	3	1.97	0.656667	0.095633
REP 12	3	2.06	0.686667	0.022533
REP 13	3	2.07	0.69	0.0171
REP 14	3	1.02	0.34	0.0091
REP 15	3	0.92	0.306667	0.013433
REP 16	3	0.61	0.203333	0.029033
REP 17	3	0.775	0.258333	0.020208
REP 18	3	0.21	0.07	0.0037
REP 19	3	0.47	0.156667	0.022633
REP 20	3	1.64	0.546667	0.168533

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
trts	0.033361	2	0.01668	0.415265	0.663125	3.244821
reps	2.709325	19	0.142596	3.549979	0.000435	1.867331
Error	1.526389	38	0.040168			
Total	4.269075	59				

Table 5: Effect of type of tree protector on tree vigor, when vigor was assessed in October 2001. Some rows were omitted from the analysis, where plant numbers were very sparse.

Anova: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
milk cartons	8	12.62	1.5775	0.204679
treepees	8	17.2	2.15	0.153086
treepros	8	16.24	2.03	0.258286
rep 1 acorns	3	6.23	2.076667	0.050633
rep 2 acorns	3	5.74	1.913333	0.495633
rep 3 acorns	3	6.83	2.276667	0.112633
rep 4 acorns	3	6.33	2.11	0.0103
rep 1 seedlings	3	5.15	1.716667	0.090833
rep 2 seedlings	3	6.14	2.046667	0.645433
rep 3 seedlings	3	5.89	1.963333	0.373333
rep 4 seedlings	3	3.75	1.25	0.0625

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Treatments	1.458433	2	0.729217	4.590049	0.029315	3.73889
Reps	2.088183	7	0.298312	1.877722	0.14952	2.764196
Error	2.224167	14	0.158869			
Total	5.770783	23				

KEY RESEARCH ACCOMPLISHMENTS

- Identified significant effect of starting plant material (acorns vs. seedlings) on survival in the first over-wintering period after planting
- Identified significant effect of starting plant material on survival during the growing season.
- Identified significant effect of type of tree protector on seedling vigor
- Demonstrated the lack of a treatment effect of tree protector on seedling survival

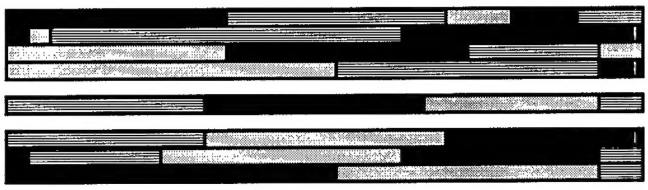
CONCLUSIONS

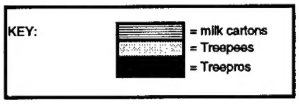
We have been able to demonstrate that Treepee® seedling protectors are statistically superior, based on the variables we measured. Acorns appear to perform better during the growing season, at least with respect to survival. However, performance overall was disappointing. A survival rate of 25% after the first year of growth is unacceptable by most standards. We have reason to believe that a large part of the poor performance was due to the challenges imposed by the supplemental irrigation provided by the creek relocation efforts of the Army Corps of Engineers (described in the last Annual Report); the lush vegetation resulting from this supplemental water appears to have resulted in high vertebrate populations in the summer of 2001 (and possibly in the preceding winter). We believe that it was these herbivores that were largely responsible for the low survival of oak seedlings.

However, the positive side of this is that we have developed a modification of the standard planting method, a method that we believe will be applicable to a variety of planting situations, and especially valuable where rodents inflict high plant mortality. While the plants are well-protected and they grow vigorously in the Treepees®, the cylindrical Treepros® (or Supertubes®, as they are called by some manufacturers) can be sunk directly into the ground to a depth of 12 inches or more. Preliminary results at this high-rodent-pressure site have suggested to us that the cylinders around the developing oak taproot offers sufficient barrier to permit improved survival and enhanced plant growth. The cylindrical shape of the tree protector above-ground encourages vertical growth up to a height of four feet or more.

Our goals are not the discovery of a radical new principal, but merely to demonstrate the performance effects of minor, cost-effective changes in planting methodology. We have demonstrated by periodic monitoring that the performance of acorns differs from that of seedlings at different times of the year. In years when acorns are plentiful, it would be more cost-effective to plant extra acorns and protect them effectively, than to start with expensive nursery-grown transplants. Treepees® and Treepros® are expensive, but they do make a difference. And we think that the underground protection that could be afforded by the cyclidrical Treepros®, using the correct installation and planting techniques, could improve plant performance even in the presence of damaging herbivore populations.

Field No.	rep no.	row no.	planting material
1	3	1	trees
1	3	2	acorns
1	3	3	seedlings
1	3	4	seedlings
1	3	5	acorns
1	3	6	trees
1	2	7	seedlings
1	2	8	trees
1	2	9	acorns
1	1	10	seedlings
1	1	11	acorns
1	1	12	trees





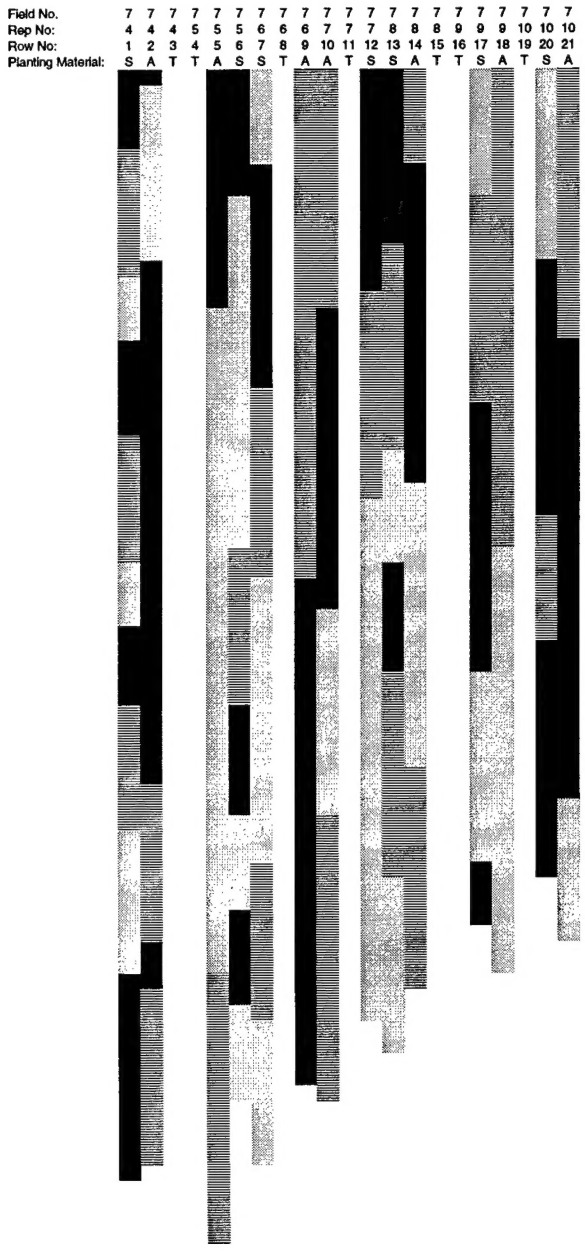


Figure 1: Field Layout of planting and treatments. Rows in Field 1 run in a generally northwest-to-southeast direction; those of Field 7 are perpendicular, and run generally northeast to southwest. Shading represents the three different tree-protection treatments, and is intended to convey the approximate arrangement, but not exact sizes, of the different blocks.